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LASER-PROTECTION EYEWEAR: PRELIMINARY RESULTS FROM COLORFASTNES--ETC(U)

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LASER-PROTECTION EYEWEAR: PRELIMINARY RESULTS FROM COLORFASTNESS TESTING

December 1976

Interim Report for Period July 1975–June 1976

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USAF SCHOOL OF AEROSPACE MEDICINE
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NOTICES

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This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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Samples of selected laser-protection eyewear were tested for a 3-month period in the colorfastness ~~part of the USAFSAM Laser-Protection Eyewear Evaluation Program~~ (described in SAM TR-76-19). Results included some moderate to severe changes in optical density (OD), measured by a laser OD system, as well as changes in haze and refraction. Some protection devices underwent severe structural changes as a result of testing. A follow-on study to determine an appropriate revised cutoff for colorfastness testing is briefly described.

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LASER-PROTECTION EYEWEAR:

PRELIMINARY RESULTS FROM COLORFASTNESS TESTING

INTRODUCTION

In mid-July 1975, after the first sample groups were completely baselined, colorfastness testing was begun on a phased basis. As noted in SAM-TR-76-19*, selection of sample groups for the first testing was based primarily on the results of a 1973 survey of the Air Force Systems and Logistics Commands.

These samples were exposed as planned for the first 3-month interval, and results range from essentially no change in some parameters to gross structural changes and damage. Both plastic and glass samples were exposed.

Further testing on these samples was halted, and, pending analysis of these early results and completion of a new pilot study, no new colorfastness testing was begun.

MATERIALS AND METHODS

Representative samples of virtually all laser-protection eyewear known to be available commercially were procured from vendors' or manufacturers' shelf stocks. No prior information relating to the purpose for this procurement was given to sources. (In cases where the same or essentially the same protector was marketed by the same or different companies, only one type was ordered.) Materials developed under Army and Air Force contracts in the early 1970's were also included in this evaluation.

Samples were prepared in two distinct manners. Glass samples were never cut; a dividing line was placed on rectangular models by an electric etching pen, and lens-shaped or round models were used intact. Plastic samples were generally cut in half, each half comprising a single sample. As with glass models, lens-shaped plastics were used intact. Locally assigned sample numbers were placed on both glass and plastic samples, individually, using the etching technique mentioned above.

Baselining was done in 1974-1975 and consisted of measuring refraction, haze, and soectrophotometric and laser optical

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*Fodor, William J. Laser-protection eyewear: An evaluation procedure. USAFSAM-TR-76-19, May 1976.

density (OD) prior to any experimentation but subsequent to sample preparation. (Equipment and techniques used to make these measurements are described in SAM-TR-76-19.) Table 1 summarizes basic information on samples that were included in this first round of colorfastness testing.

TABLE 1. SUMMARY TABLE

Local sample-series number	Mfgr.	Model number	Composition
1	AO	698	C
2	AO	599	C
3	AO	581	C
6	AO	584	C
7	AO	598	G
10	AO	587	G
14	GO	LGS-A	P
15	GO	LGB	P
18	GO	A7338-1	P
26	BL	5W3755	G
27	BL	5W3756	G
28	BL	5W3754	G
29	BL	5W3757	G
35	AO	575	G

Key: AO - American Optical (Vendor: Laser, Inc.)

GO - Glendale Optical

BL - Bausch and Lomb

C - combination (glass and plastic)

G - glass

P - plastic

Actual colorfastness testing was begun in a staggered fashion in mid-July through October 1975, with several samples of three different sample-series placed in each of the Atlas model WR-6000 Weatherometers. Sample entry was staggered to evenly distribute the workload involved in remeasuring the samples, especially the amount of work involved in laser OD measurement.

Each Weatherometer was maintained at $59° \pm 1°$ C black panel temperature and with constant illumination; Weatherometer #1 was maintained at $\leq 20\%$ relative humidity, and #2 at $\geq 85\%$.* Samples were mounted in custom-made sample holders designed and fabricated by the USAF School of Aerospace Medicine Fabrication Branch. These sample holders, in conjunction with the Weatherometer racks, kept each sample at a constant level of illumination.

Each sample was exposed for 90 days. Following this period, samples were remeasured for haze, refraction, laser OD, and gross structural changes.

RESULTS

Tables 2 and 3 contain summaries of the indicated-parameter averages (except as noted) from Weatherometers #1 and #2, respectively. With both Weatherometers, series 14 showed a large decrease in laser OD. For the other series, a few showed some increase in OD while others showed a slight decrease. Figure 1, a photograph of three samples of series 14, shows the large color change in this series. In series 15, even though definite loss of color is apparent in samples (Fig. 2), only a slight increase in OD is indicated in Tables 2 and 3.

Other notable results in Weatherometer #2 samples are the very large increases in the percent haze and the relatively minor magnitude refractive error changes.

Grossly, Figure 3 shows the difference in severity of structural changes induced by Weatherometer #2 over those induced by Weatherometer #1.

Figure 4 shows, under magnification, the difference in surface effects between Weatherometers 1 and 2 on sample 18, a plastic. Figure 5 is a magnification of the damage visible in Figure 3 for series 26. Figure 6 shows magnifications of changes in the interference filter layer of samples 27 and 29, respectively; both resulted from Weatherometer #2. Transmitted diffuse white light was used for all photographs except Figure 5, which was made using transillumination.

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*ibid, p.6.

TABLE 2. SUMMARY TABLE OF AVERAGED RESULTS, PRE- AND POSTEXPOSURE IN WEATHEROMETER #1, FROM 6 SAMPLES OF EACH SERIES

Local sample-series number	Haze (%) Illum. source A Pre-	Haze (%) Illum. source A Post-	Haze (%) Illum. source C Pre-	Haze (%) Illum. source C Post-	Refractive power (diopters) Magnitude of change	Laser OD λ(nm)	Laser OD Pre-	Laser OD Post-
1	0.50	2.44	0.47	2.52	0.01	-	NM	NM
6	0	2.02	0	3.00	0.01	694	6.12	6.09
7	4.21	5.00	4.54	5.95	0.03	470	>6.24	>6.24
						515	7.21	6.19
10	0	0	0	0	0.01	633	4.16	4.99
14	0.98	5.82	1.22	5.33	0.01	488	>7.17	0.46
						515	5.31	0.59
15	0.09	4.19	0.79	4.32	0.04	515	5.25	5.39
18	1.96	5.30	2.07	5.12	B	488	>7.17	7.07
						515	5.75	6.31
26	2.40	7.85	3.01	7.76	0	-	NM	NM
27	0	0	0	2.89	0.01	694	NM	>5.15
28	0	0	0	0	0	488	NM	>6.24
						515	NM	6.45
29	0	0	0	0	0	-	NM	NM
35	0	1.66	0.25	3.62	0	633	NM	2.75
						694	NM	6.35

NM--Not measured
B--Could not be measured due to high absorbance

TABLE 3. SUMMARY TABLE OF AVERAGED RESULTS, PRE- AND POSTEXPOSURE IN WEATHEROMETER #2, FROM 6 SAMPLES OF EACH SERIES

Local sample-series number	Haze (%) Illum. source A Pre-	Haze (%) Illum. source A Post-	Haze (%) Illum. source C Pre-	Haze (%) Illum. source C Post-	Refractive power (diopters) Magnitude of change	λ(nm)	Laser OD Pre-	Laser OD Post-
1	0.78	39.91	0.86	40.85	D	-	NM	NM
2*	0	6.5	0	6.5	0.01	470	>5.73	>5.73
						515	5.45	5.97
3	0	13.2	0	27.8	0	633	4.52	4.87
6	0	5.92	0	6.53	0.01	694	5.75	6.07
14	2.22	25.57	2.48	26.85	0.01	488	>7.17	1.5
						515	>7.17	0.46
15	1.02	20.45	0.47	20.96	0.04	515	5.25	6.06
18	1.96	23.68	2.06	20.55	B	488	>7.17	6.98
						515	5.28	6.28
26	2.40	68.34	3.01	70.60	0	-	NM	NM
27	0	89.38	0	89.58	D	694	NM	>5.15
28	0	30.47	0	27.72	0.01	488	NM	>6.24
						515	NM	6.56
29	0	33.47	0	49.27	0	-	NM	NM
35	0	75.67	0.25	76.43	D	633	NM	5.32
						694	NM	>6.76

NM--Not measured

D--Sample could not be measured postexposure due to significant structural changes

B--Could not be measured due to high absorbance

Only two samples tested

DISCUSSION

The lack of definitive OD change in series 15 is interesting in view of the very noticeable color changes in the sample. It appears that the increase in haze, which represents increased scattering, results in a net decrease in transmitted light reaching the detector used in laser OD measurements, even given a probable increase in transmitted light due to OD decrement. This is the likely cause of laser OD increases shown in samples.

Haze increase, while expected in plastic (especially from Weatherometer #2), was also seen in glass. Some of the haze increase can be attributed to a layer of unknown material which was deposited, apparently preferentially, on glass. Scrapings of this material were taken and analyzed by atomic absorption spectroscopy and mass spectrometry, along with samples of the deionized water which provides humidity. This substance could not be identified from these tests. Glass stability, or rather the lack of stability, is likely the reason for haze increase in glass samples. Other structural changes in glass were inspected, but upon reflection should have been predicted, notably in the interference film devices, series 26-29, inclusive.

Changes in the magnitude of refractive errors in plastics were not unexpected because of the heat maintained in the chambers. More significant was the absence in plastics of any residue which would have indicated leaking of the dye out of the substrate. This speaks well for the inherent stability of the substrate, even though the organic dyes tend to lose color upon exposure in Weatherometers.

An overall impression derived from these preliminary results is that the initial experimental design was much too severe for the samples. This is supported to an extent by the fact that 1 year of exposure under the above outlined conditions is equivalent to between 3.5 and 8 years of 24-hour daily exposure outdoors, depending on geographical location.* Thus, it appears that a revision of the colorfastness portion of the evaluation procedure described in SAM-TR-76-19 should be undertaken.

A pilot study has been initiated to study the rapidity of sample degradation. Samples of both glass and plastic devices are included. Upon completion of this pilot study, a revision to perhaps as little as 100-150 hours of exposure will be made, and the colorfastness testing resumed with fresh samples.

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*Atlas Electric Devices Co., Chicago, Ill. Personal communication, March 1976.

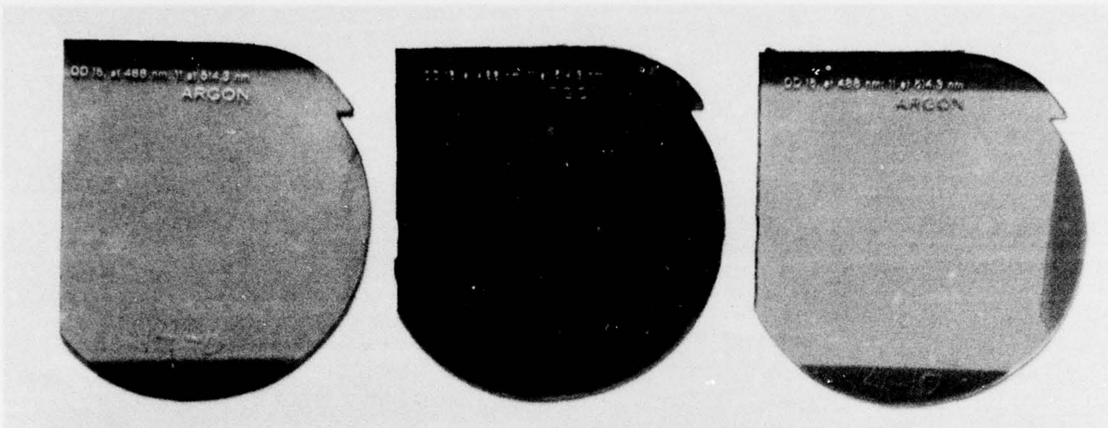

Figure 1. Laser OD changes in sample-series 14 (left to right): Weatherometer #2, control, Weatherometer #1.

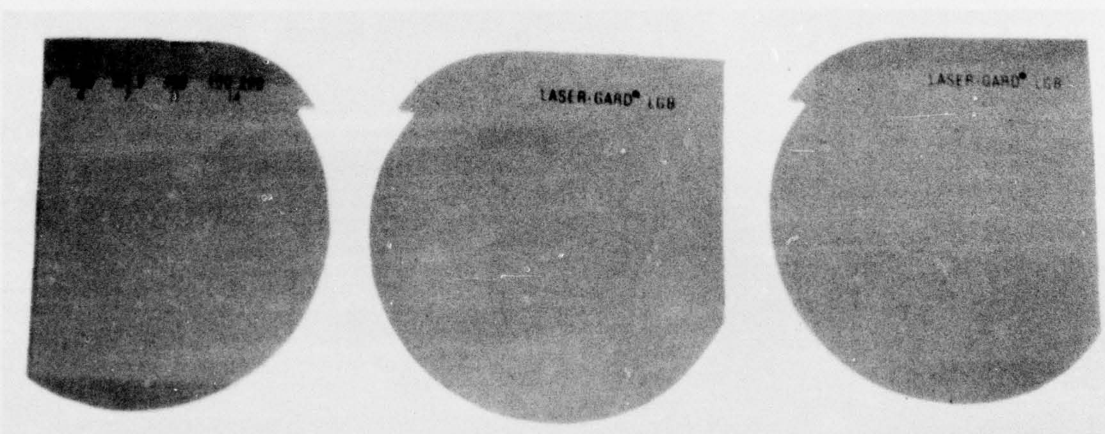

Figure 2. Loss of color in sample-series 15 (left to right): Weatherometer #2, control, Weatherometer #1.

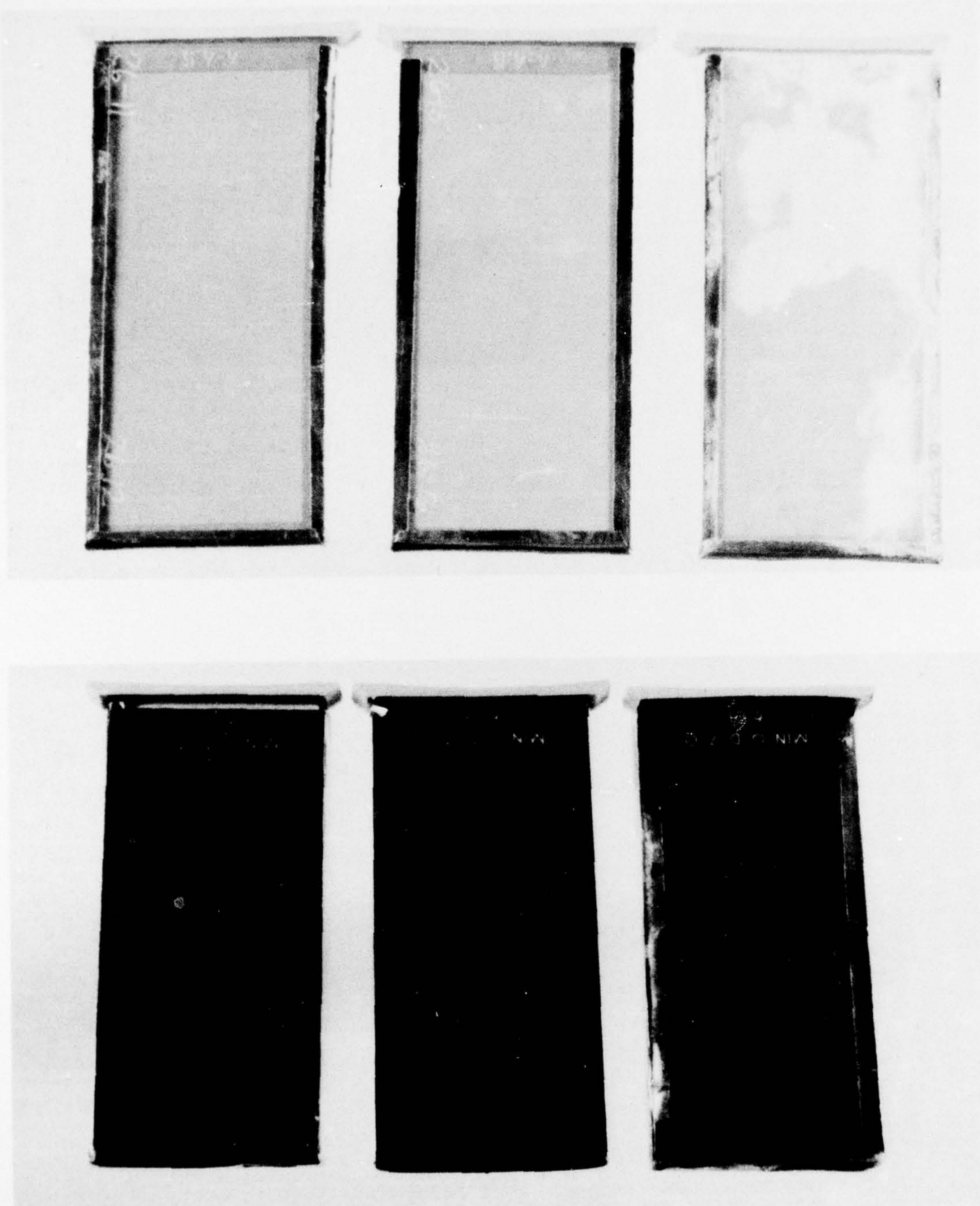

Figure 3. Comparison of structural changes induced in sample-series 26 (top) and 27 (bottom) by Weatherometers (left to right): Weatherometer #1, control, Weatherometer #2.

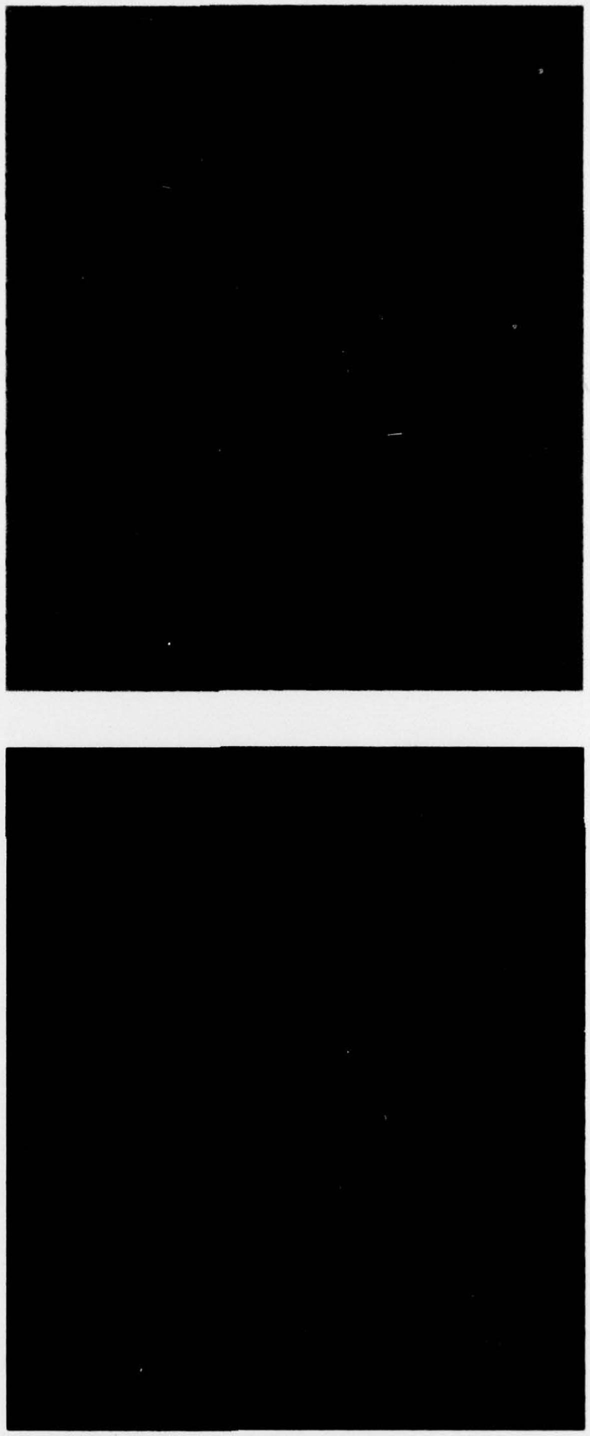

Figure 4. Surface effects on sample-series 18 from Weatherometer #1 (8.75x, top) and Weatherometer #2 (8.75x, bottom).

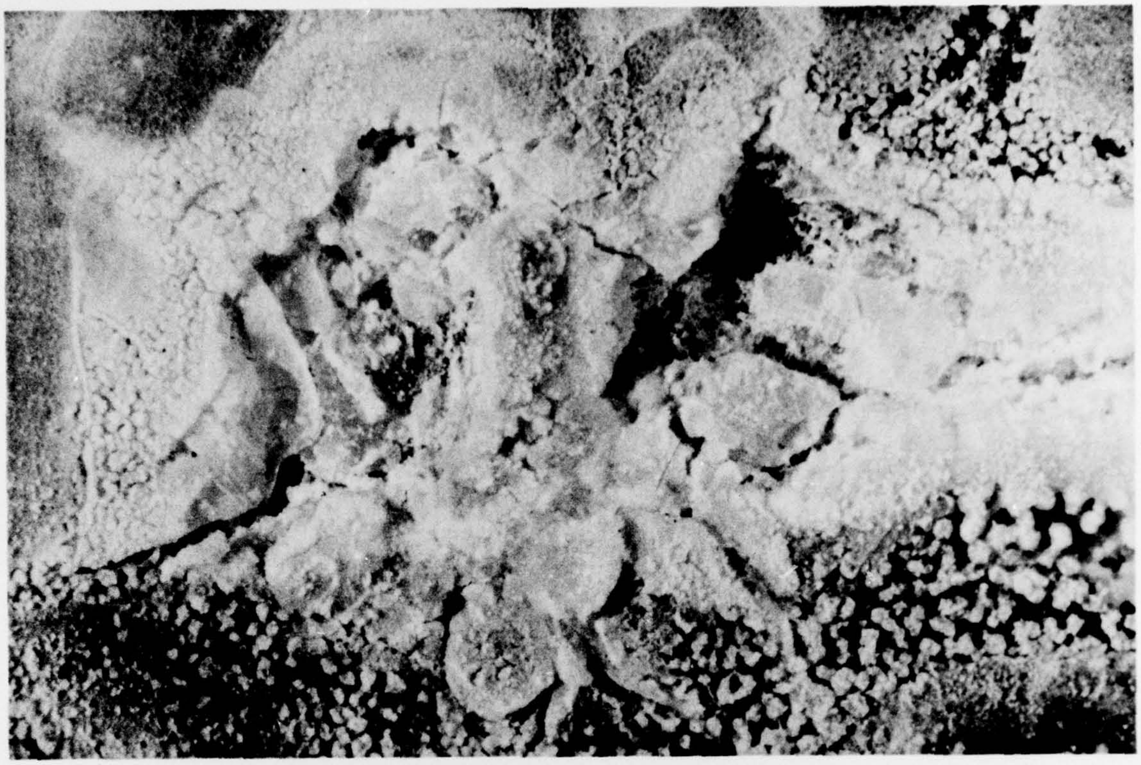

Figure 5. Structural damage in sample-series 26 from Weatherometer #2 (8.3x).

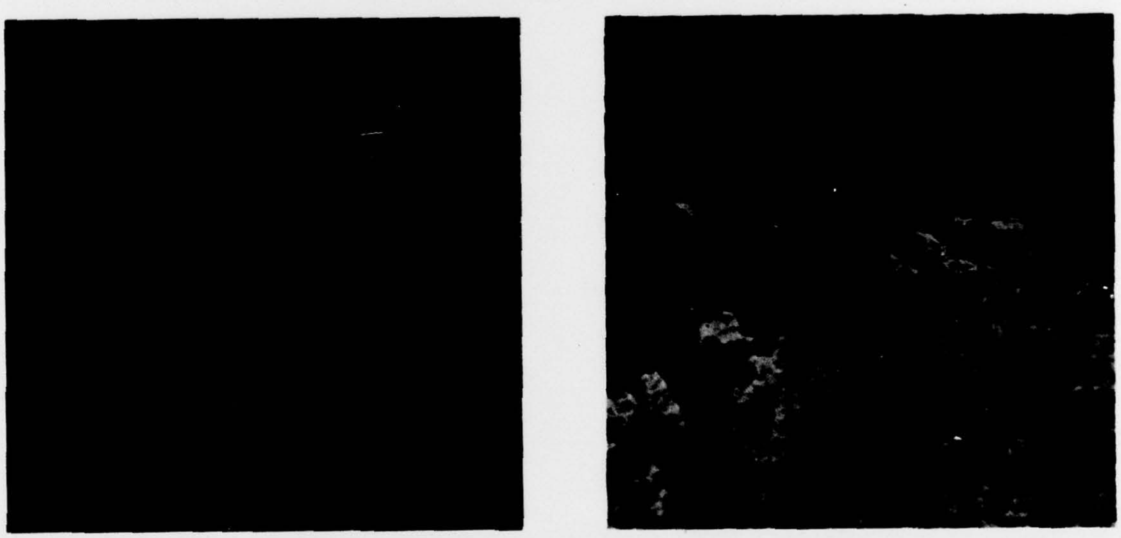

Figure 6. Degradation in interference film of sample-series 27 (8.25x, left) and 29 (8.35x, right) from Weatherometer #2.

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